DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with
ALASKA WATER STUDY COMMITTEE
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NATURAL RESOURCES, DIVISION OF GEOLOGICAL
AND GEOPHYSICAL SURVEYS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-620 (SHEET 2 OF 4)

GROUND WATER

The schematic sections in this column show aquifer conditions in various areas of the Cook Inlet basin. Vertical distance is greatly exaggerated.

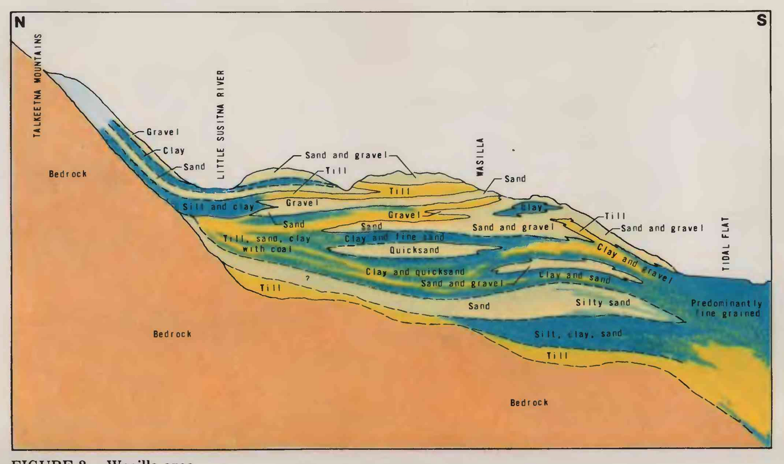


FIGURE 3.—Wasilla area.

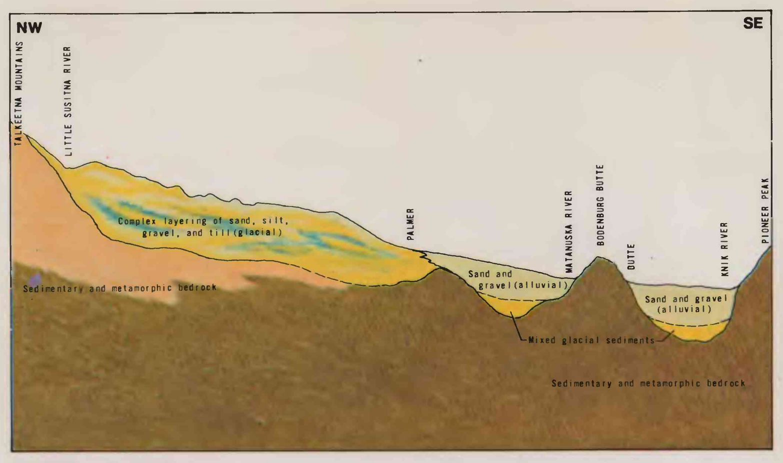


FIGURE 4.—Palmer-Butte area.

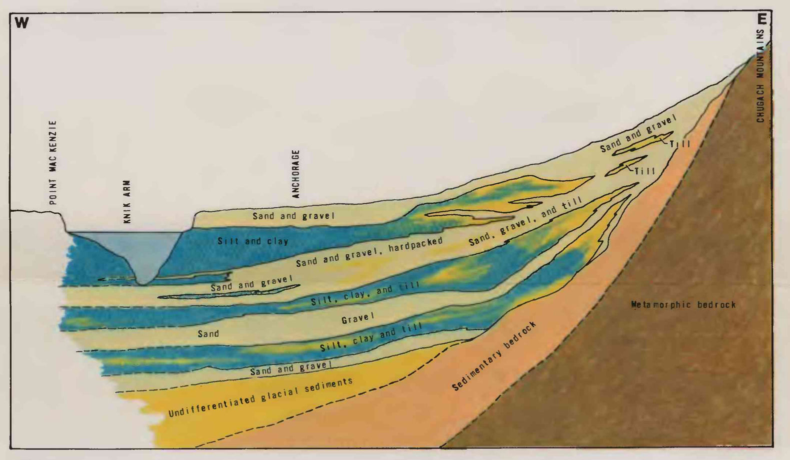


FIGURE 5.—Anchorage area.

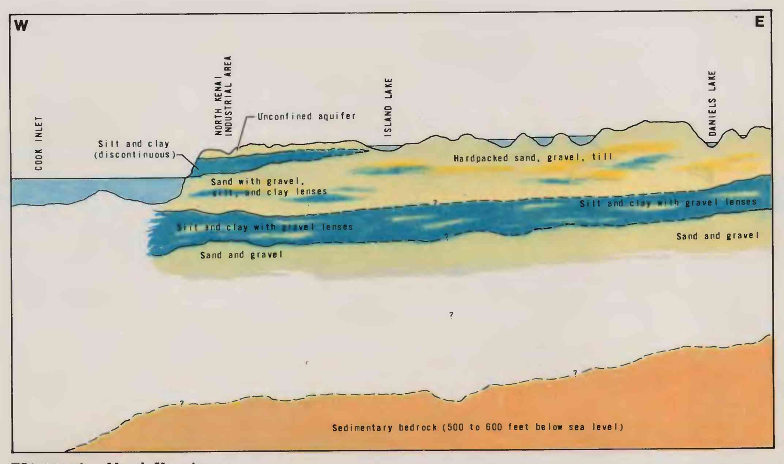


FIGURE 6.—North Kenai area.

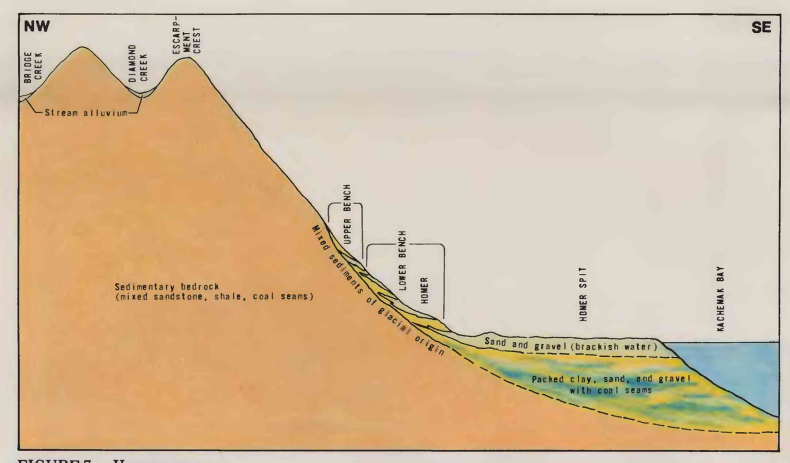


FIGURE 7.—Homer area.

Aquifers and their potential

Aquifers used for domestic, industrial, and public water supplies in the Cook Inlet basin vary widely in the hydrologic characteristics that determine water-yielding potential. Knowing the size and hydraulic properties of aquifers and the availability of recharge generally leads to a relatively confident prediction of the potential yield of any given aquifer. However, stratigraphic complexities normally associated with glacially derived deposits cause great variability in physical characteristics within individual aquifers and give rise to various degrees of hydraulic connection between aquifers. Discontinuities and variable hydraulic conductivity in confining layers affect leakage between aquifers and ground-water storage capacity. As a result, an aquifer's potential yield is greatly dependent on the characteristics of adjoining confining beds (less permeable deposits) and aquifers.

Five schematic sections (figs. 3-7) illustrate the variety of aquifer systems beneath the most populous areas of the basin. In each system the aquifer interconnection, recharge sources, and size are dissimilar, yet hydraulic characteristics of individual aquifers can be quite similar.

In the Matanuska Valley near Wasilla, extensive domestic development has occurred in the past 10 years. The aquifers underlying the area are interfingered with silt, clay, and till beds (fig. 3) produced during marine, glacial, and alluvial deposition. During the early development of the area the shallowest aquifer system, that available to hand-dug wells, was used. As development progressed, deeper wells were drilled to obtain water of better quality and higher yields and to reduce the potential of pollution from waste disposal systems. The large water supplies needed for schools and commercial operations are now obtained from some of the deepest and most productive confined aquifers underlying the area. The areal extent of these aquifers is not yet defined.

Recharge in the Wasilla area is from several sources. Shallow aquifer zones mostly unconfined by silt or clay layers derive most recharge from lakes, streams, and infiltrating precipitation. The deeper confined aquifers must rely on leakage through the confining layers from adjacent aquifers for their major source of recharge. Some confined aquifers may have additional recharge at some distance upgradient where they are exposed to surface-water sources.

Well yields near Wasilla vary with depth and geographic location and with design of the well. Generally, yields are higher [50-300 gal/min (gallons per minute)] in deeper confined aquifers than in the shallower zones (1-50 gal/min).

The schematic section of the Palmer-Butte area (fig. 4) differs from that at Wasilla in that the deposits beneath the present valley floors of the Matanuska and Knik Rivers are generally unconfined; that is, ground water exists under atmospheric pressure. Till sheets and less permeable lenses cause some local confinement, but nearly the entire area is readily rechargeable by infiltrating precipitation and seepage from the Matanuska and Knik Rivers. Numerous bedrock outcrops indicate that the thickness of alluvium is not great. Ground water is being withdrawn from relatively continuous sand-and-gravel beds in outwash deposits and Holocene stream alluvium (Trainer, 1960). Well yields range from 5 to 75 gal/min in areas away from large recharge sources and (or) where localized confinement occurs; yields may exceed 4,000 gal/min in alluvium adjacent to present rivers.

By far the greatest development of ground-water resources has taken place in the Anchorage bowl where more than 3,000 wells penetrate various aquifers (fig. 5). The two best defined aquifer systems are an unconfined system, usually less than 30 ft below land surface, and a system beneath an extensive confining silt and clay layer. The unconfined system is virtually continuous throughout the Anchorage area. It is recharged by infiltrating precipitation, by seepage from several streams transecting the area, and by leakage from the underlying confined aquifer. Well yields range from 200 to 2,000 gal/min in the alluvial fill of Ship Creek and Campbell Creek but are much lower in domestic wells not located in the valley fills.

The confined aquifer system is used to supply the Municipality of Anchorage, two military bases, and numerous commercial and industrial endeavors. The system consists of two or more aquifers hydraulically connected. Yields are generally greater than 750 gal/min but decrease as the aquifer sediments grade to finer grained materials south of Campbell Creek and north of the military bases. Recharge for these confined aquifers is most likely to be by infiltration from streams and precipitation along the foot of the Chugach Mountains where there is no confining layer and by leakage from the unconfined aquifer system down through the confining layers.

Ground water in the North Kenai area (fig. 6) is supplied by aquifers in the unconsolidated Quaternary sediments which are 500 to 600 ft thick. The uppermost aquifer is unconfined and supplies almost all the private homes and part of the industry of the area. Well yields range from 10 to 75 gal/min for the domestic wells and from 200 to 600 gal/min for the larger industrial wells. Recharge is almost exclusively from infiltrating precipitation and the numerous lakes. The uppermost confined aquifer is well defined adjacent to the coastline. Confinement may become discontinuous farther inland, and hydraulic connection between this and the uppermost aquifer system may be direct. Well yields for the uppermost confined aquifer range from 10 to 1,200 gal/min. Only a few industrial wells withdraw water from a deeper confined aquifer, and yields in these wells range from 50 to 2,000 gal/min.

Most of the Homer area (fig. 7) is underlain at shallow depths by the Tertiary Kenai Formation which in that area consists of sand, silt, clay, and lignite lenses (Waller, Feulner, and Morris, 1968). Quaternary sediments are found in the stream valleys and on benches adjacent to Cook Inlet. Most of the wells in the Kenai Formation yield less than 10 gal/min in the bench areas and more than 50 gal/min north of the escarpment crest. Typical well yields from Quaternary deposits range from 5 to 25 gal/min.

Surface- and ground-water relationships

The interchange of water between the surface water and aquifers forms an integral part of the hydrologic cycle of a basin. This interchange is constantly occurring but is most evident during low-streamflow periods and during long periods of lower than normal precipitation. During these minimum flows, streamflow is derived almost entirely from the unconfined ground-water reservoir. When streamflow is augmented by snow and ice melt or direct runoff from increased precipitation, the flow from ground-water sources becomes less significant. Water removed from ground-water storage during the low flow period can be restored by infiltration. The magnitude of minimum flow per unit area of a stream's drainage basin can be a general indicator of an unconfined ground-water potential for that area. On sheet 4, the map of minimum discharge shows a greater minimum flow per unit of area on the western side of the Susitna basin and the western side of Cook Inlet than in the remainder of the study area. However, there is little ground-water information to support the higher ground-water potential that the minimum discharges seem to indicate.

Seepage investigations are a means of measuring quantities of water interchanged between streams and ground-water reservoirs. The investigations include nearly simultaneous discharge measurements along a reach of a stream, usually during a low-flow period. Water losses and gains for reaches of the stream between sites of discharge measurements can then be calculated. Seepage investigations cannot be used to predict ground-water potential, but they can give a relative indication of how permeable the alluvial materials of a stream valley are and whether the unconfined ground-water level is above or below the level of the stream. Generally, a stream gains water where the water table adjacent to the stream is higher and it loses water where the water table is below the stream level.

Seepage investigations have been performed on four streams in the Cook Inlet basin. Figure 8 shows the gain or loss of water per mile of stream length for stream reaches between sites of discharge measurements. Twenty seepage investigations have been performed on Ship Creek, but only the most detailed is shown. Data for the remaining 19 were given by Scully and others (1978).

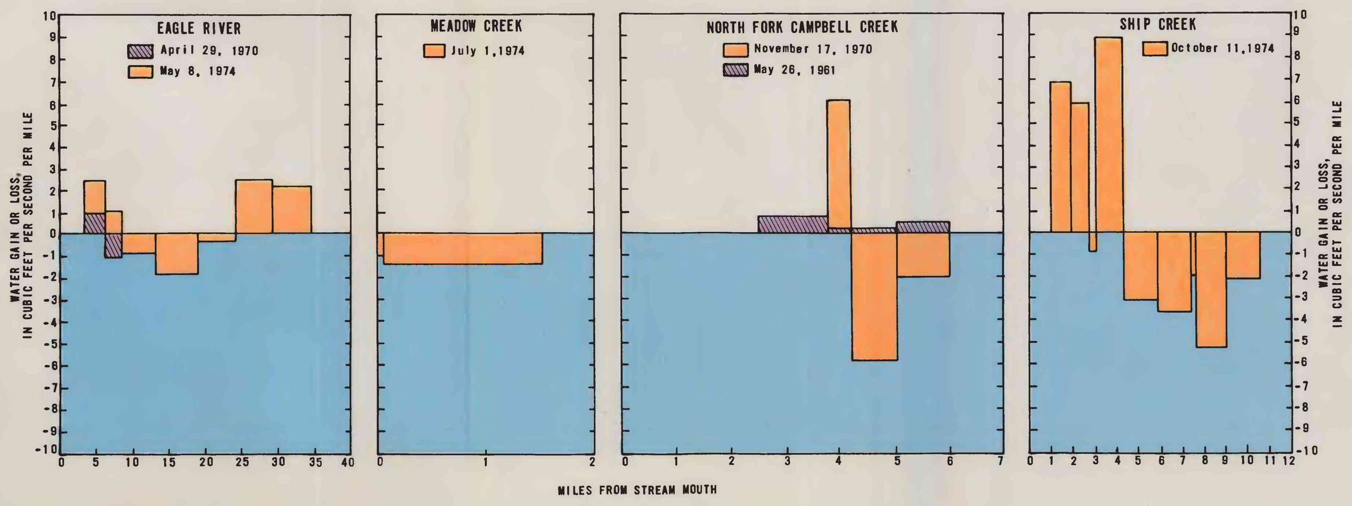


FIGURE 8.—Relative stream gains and losses per mile of stream length for four streams near Anchorage, Alaska.

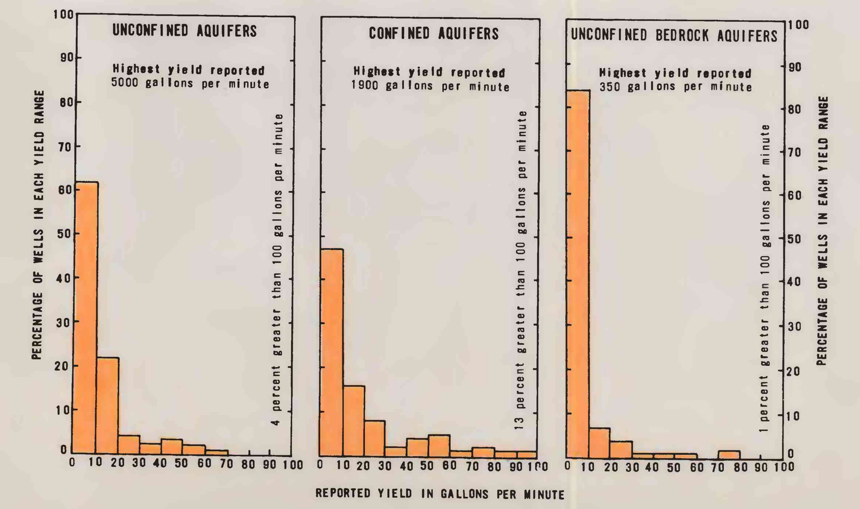


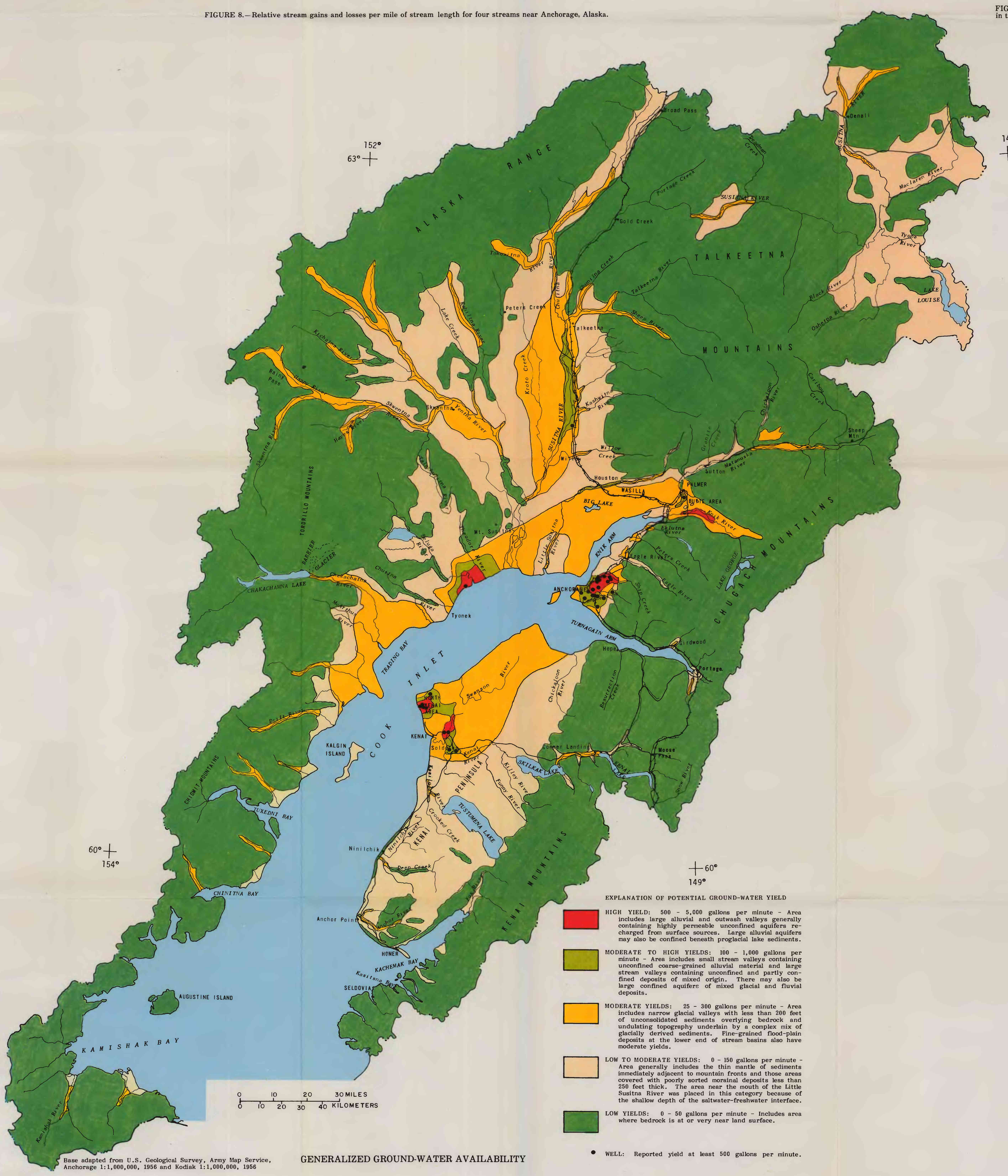
FIGURE 9.—Distribution of reported well yields in unconfined and confined aquifers in the unconsolidated sediments and in bedrock materials.

Ground-water availability

Sediments of the Cook Inlet basin contain ground water in both confined and unconfined aquifers. Ground water in a confined aquifer is under a pressure greater than atmospheric, while ground water in an unconfined aquifer is under atmospheric pressure. Yield characteristics of these two types of aquifers in the study area are similar (fig. 9). Confined aquifers have a wider range of yields, but maximum yields of existing wells are less than those in unconfined aquifers.

The general availability of ground water is shown on the large map. Zones are differentiated according to their suspected potential for yielding ground water from both confined and unconfined aquifer systems. The most favorable areas for high-yield wells are those having coarse-grained alluvial material near major rivers and those underlain by thick, extensive confined aquifers which have ample opportunity for being recharged. Lower potential is assigned to areas where sediment thickness is less, recharge is likely to be limited, or aquifer systems are thought to be areally limited by depositional conditions. The lowest ground-water yield potential is assigned to the bedrock materials. Yield there varies according to degree of fracturing, extent of cementation of sedimentary formations, and the availability of recharge. The last bar graph in figure 9 shows how yields are distributed in wells finished in bedrock. For the most part, wells finished in bedrock have either very low initial yields or a low capacity for sustaining an initial yield. Yield potential for areas where subsurface data are absent or meager can only be inferred from the surficial geology and the suspected depositional history.

Ground-water availability is categorized into five general ranges of well yield. Individual wells may have yields outside the range shown.



EXPLANATION OF POTENTIAL GROUND-WATER YIELD

HIGH YIELD: 500 - 5,000 gallons per minute - Area includes large alluvial and outwash valleys generally containing highly permeable unconfined aquifers recharged from surface sources. Large alluvial aquifers may also be confined beneath proglacial lake sediments.

MODERATE TO HIGH YIELDS: 100 - 1,000 gallons per minute - Area includes small stream valleys containing unconfined coarse-grained alluvial material and large stream valleys containing unconfined and partly confined deposits of mixed origin. There may also be large confined aquifers of mixed glacial and fluvial deposits.

MODERATE YIELDS: 25 - 300 gallons per minute - Area includes narrow glacial valleys with less than 200 feet of unconsolidated sediments overlying bedrock and undulating topography underlain by a complex mix of glacially derived sediments. Fine-grained flood-plain deposits at the lower end of stream basins also have moderate yields.

LOW TO MODERATE YIELDS: 0 - 150 gallons per minute - Area generally includes the thin mantle of sediments immediately adjacent to mountain fronts and those areas covered with poorly sorted morainal deposits less than 250 feet thick. The area near the mouth of the Little Susitna River was placed in this category because of the shallow depth of the saltwater-freshwater interface.

LOW YIELDS: 0 - 50 gallons per minute - Includes area where bedrock is at or very near land surface.

• WELL: Reported yield at least 500 gallons per minute.

0 10 20 30 MILES
0 10 20 30 40 KILOMETERS

Base adapted from U.S. Geological Survey, Army Map Service, Anchorage 1:1,000,000, 1956 and Kodiak 1:1,000,000, 1956

GENERALIZED GROUND-WATER AVAILABILITY

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WATER RESOURCES OF THE COOK INLET BASIN, ALASKA

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